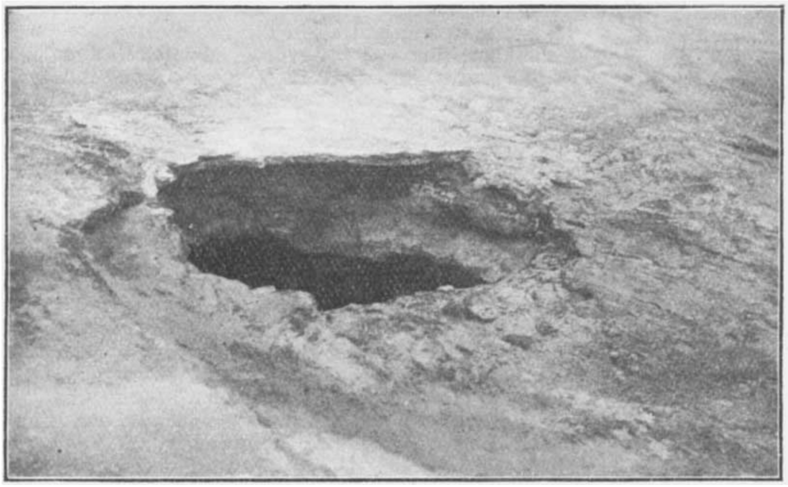
observed growing, there the issuing gases or encrustants contained ammonia; while, conversely, an active area not supporting algæ proved to have no trace of ammonia in its emanations or encrustants.

In connection with the presence of hydrofluoric acid, the deposits of sulphates, such as alum, are very significant. Potassium alum, appearing as lichen-like growths after every rainfall, covered the surface of the ash over many of the areas of activity. Sulphuric acid is a strong disintegrating agent, and its presence in the emanations gives a key to the formation of hydrofluoric and hydrochloric acids, for sulphuric acid acting on fluorides and chlorides sets free the more volatile halogen acids.

The volcanic ash and pumice which constitute the mud-flow have been highly altered by the passage of the volcanic gases. Analysis shows that in the vicinity of the vents the ash has lost a portion of its silica content, while the iron, calcium, and magnesium have been relatively concentrated. Sometimes the ash and pumice are completely disintegrated. Superheated steam containing halogen acids is a disintegrating agent that even rhyolite cannot withstand. The presence of so many large vents, tunnels, and channels in the mud-flow may well be attributed to the action of the volcanic gases.



Photo] [*J. W. Shipley.*

FIG. 4.—A typical volcanic vent. The gases were escaping from another hole some distance away along the horizontal tunnel. Note the thickness of the encrustants covering the tunnel. They consisted of silica, sulphur, fluorides, and compounds of iron.

The nature of the emanations, and the continuous evolution of heat and gases for seven years, with little indication of any diminution in volume, indicate direct magmatic origin for the phenomena of this valley. The extrusion of semi-fluid lava from Novarupta and in the bottom of the Katmai crater may signify a similar approach of the magma to the surface in the Valley of Ten Thousand Smokes.

J. W. SHIPLEY.

Chemical Department, University of
Manitoba, Winnipeg.

The Control of Scientific and Industrial Research.

ANNOUNCEMENT is made in NATURE of January 29 of the appointment of Mr. R. L. Frink to be director of research of the Glass Research Association, which has recently been formed as one of the Industrial Research Associations of the Department of Scientific and Industrial Research. The appointment raises a question which has intimate relations with scientific interests and progress, and it should not be permitted to pass without protest.

It has always been urged in the columns of NATURE, and accepted as a cardinal principle by men of science generally, that scientific research can only be rightly understood and sympathetically promoted by a director who has himself taken part in it. The essential qualification, therefore, of a director of research of each of the industrial research associations should be proved capacity for research; for without such aptitude the work undertaken is bound to be narrow, and the scientific aspects upon which progress ultimately depends to be neglected. This point of view, however, seems to have received secondary consideration only in the recent appointment; for what the secretary of the Glass Research Association says as to the qualifications of the director of research is: "Mr. Frink has a lifelong experience of the American glass trade and glass research, is well known to the foremost English glass manufacturers, and his appointment is welcomed by the British glass industry."

It is scarcely too much to say that this appointment has been received with intense astonishment by all scientific men connected with the glass industry, and by many glass manufacturers as well. In the glass industry, more, perhaps, than in any other, it was naturally expected that a director of research would be a man of distinguished eminence whose work was of proved scientific value; yet practically no such evidence is forthcoming in the case of Mr. Frink.

A scientific friend in America, who is recognised as one of the first authorities upon scientific matters connected with glass, tells me that Mr. Frink is not known as a research man or in research circles, but that he is highly spoken of by practical glass-makers "as a man of long experience in the window-glass trade who is accustomed to be called in as 'first aid' for furnace troubles, colour troubles, and like technical difficulties. This trade he has pursued for some years with success, and his reputation in this domain is among the best. He maintains a so-called laboratory and has a number of technical assistants, and, I fancy, has gathered together a considerable amount of rough-and-ready wisdom which has found extensive application in an industry where research laboratories have hardly been thought of until recently."

It seems quite possible that the Glass Research Association has secured the services of a very able, practical man, but in making the appointment the council of the association has negatived the policy elaborated with such care in the article published in NATURE of November 13 last: "The ideal director for this association is not an individual research worker whose glory is to work in splendid isolation; but is he who will bring *expert knowledge of the methods of scientific research* to bear upon these complex problems, who possesses such personality as to attract promising young research workers to his side . . . and to co-ordinate the efforts being made through the various laboratories, institutions, and works to which specific research and experimental work will be allotted." (Italics are mine.)

If the writer of that article, the temporary secretary of the association, had been a scientific man, he

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would have realised that our greatest investigators rarely "work in splendid isolation," but that only a man who has proved his capacity as an investigator can lead and co-ordinate research. It is certain that British scientific men will not submit to control and direction from the practical man; thus a definite breach is opened between science and an important branch of industry.

It has not been sufficiently clearly realised that scientific and industrial research is passing out of the control of the recognised scientific and technical societies and institutions and of the universities into the hands of the Department of Scientific and Industrial Research, and, in accordance with Government policy, the secretary of this Department is an administrator without practical knowledge of science, industry, or research. The associations which are formed under the ægis of the Department are governed by councils upon which organised science is unrepresented, but to which the Department may nominate scientific men. To the council of the Glass Research Association the Department has nominated two scientific representatives, one of whom is in India. On the executive committee science is not represented; and when this appointment was discussed between that body and the secretary of the Department, the scientific aspects of the case can have received no consideration. As the Department controls funds for research which are vastly greater than those at the disposal of the Royal Society and all the other societies and universities put together, the outlook for science is a poor one unless scientific men are prepared to take united action with the view of securing a proper share in the control of research.

MORRIS W. TRAVERS.

The Predicted Shift of the Fraunhofer Lines.

MAY I submit the following two propositions for the consideration of relativists?

(1) An occurrence takes place at a point S. Light-signals are dispatched from S at the beginning of the occurrence to two observers A and A′, and signals are again dispatched at the conclusion of the occurrence. By means of these A and A′ measure the time of the occurrence to be dt and dt' respectively. Then

$$\sqrt{g_{44}}.dt = \sqrt{g'_{44}}.dt',$$

where g_{44} and g'_{44} are the values of Einstein's 44 potential at A and A′.

(2) An occurrence takes place at S, and is measured by an observer there to take the time dt. Another occurrence takes place at S′, and is measured by an observer there to take time dt'. By means of light-signals dispatched from S and S′ at the beginning and conclusion of each occurrence, an observer A measures the times of each occurrence to be equal. Then

$$\sqrt{g_{44}}.dt = \sqrt{g'_{44}}.dt',$$

where g_{44} and g'_{44} are the values of Einstein's 44 potential at S and S′.

Prop. (1) seems to be a correct inference from Einstein's theory, and prop. (2) is deduced by applying (1) to the occurrence at S as measured by S and A, and then to the occurrence at S′ as measured by S′ and A.

If these propositions are sound, how does the Einstein theory predict the displacement of the solar lines? For it seems to me that the criterion for "similarity" of two radiating mechanisms in different parts of a gravitational field is that the invariant space-time elements corresponding to one oscillation of each should be equal. For two mechanisms at rest in the field this condition reduces to $\sqrt{g_{44}}.dt = \sqrt{g'_{44}}.dt'$.

JAMES RICE.

University of Liverpool.

EINSTEIN'S prediction of a shift of the Fraunhofer lines to the red can be analysed into two assertions:—(1) That the period of vibration of an atom at rest on the sun differs from that of a similar terrestrial atom; and (2) that this difference is preserved unchanged by the light-waves travelling from the solar atom to the earth, so that it is revealed by a comparison made in a terrestrial laboratory. It is the second assertion that is challenged by Mr. Rice; and, so far as I can make out, the same objection was at the root of the criticisms formerly made by Sir Joseph Larmor. Since criticism centres entirely round the second assertion, I will deal with it solely. I may state, however, that although I regard the first assertion as highly probable, I do not regard it as proved with complete rigour; and had the criticism been directed against this, I should have been much less willing to take sides in the controversy.

The interval ds between two events is a quantity having an absolute significance independent of co-ordinate systems; and when the two events take place at the same place, $ds = \sqrt{g_{44}}.dt$. Mr. Rice's first proposition states that if we have two light-pulses travelling from the sun to the earth, the interval ds between their passages through any point is the same all the way along the track. The statement has a certain appearance of plausibility, but I cannot see any definite argument in favour of it. Space-time round the sun is non-Euclidean; the geodesics have, accordingly, defined but rather complicated tracks, and there need be no constancy of interval between points on neighbouring geodesics. The rule deduced from Einstein's theory for comparing the passage of two light-pulses at the points A and A′ respectively is not $ds = ds'$, but $dt = dt'$, *provided the co-ordinates used are such that the velocity of light does not change with* t.

If we found that the velocity of light changed secularly, we should at once condemn our time-reckoning as non-uniform; accordingly, the proviso is satisfied in practice. With the co-ordinates most commonly adopted the velocity of light is $1-2m/r$, which depends on the position r, but not on the time t. Then if t_1 and t_2 are the times of the two pulses at r, t'_1, t'_2 the times at r', since the mean velocity of the first pulse $(t'_1-t_1)/(r'-r)$ has to be the same as the mean velocity $(t'_2-t_2)/(r'-r)$ of the second pulse, over the same course but at a later time, it follows at once that $t'_2-t'_1$ is equal to t_2-t_1, which proves the statement made. The time between the two light-pulses is preserved unchanged on the journey from the sun to the earth.

In his letter (NATURE, January 22, p. 530) Sir Joseph Larmor describes this condition, that the velocity of light (or the formula for ds) shall not contain the time explicitly, as "a reasonable assumption." I cannot see that any assumption is involved; nor can I agree that it is of "an absolute type." The well-known expression

$$ds^2 = -(1-2m/r)^{-1}dr^2 - r^2 d\theta^2 - r^2\sin^2\theta d\phi^2 + (1-2m/r)dt^2 \quad . \ . \ . \quad (A)$$

is, in the first place, simply a particular integral of Einstein's differential law of gravitation. It can be shown that it is an appropriate solution for the case of an isolated particle. But there is a fourfold infinity of other solutions applicable to the same case; so there can be nothing absolute about this solution, or about the co-ordinates r, θ, ϕ, t which it defines. It is, in fact, often more convenient to write $r=r'+m$,

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